CLAIMS

1. A dual rate echo canceller for applications with asymmetric transmit and receive rates, the echo canceller comprising:

an echo canceller filter having an input adapted to receive a transmit signal from a transmit path at an input, the echo canceller filter being adapted to generate an output signal comprising a signal component representative of an echo signal associated with the transmit signal at an output, wherein the input and the output of the echo canceller filter are sampled at a transmit rate;

a first rate matching block having an input adapted to receive the echo cancellation filter output signal, the first rate matching block being adapted to generate a first output, the first output being subtracted from an incoming receive signal yielding a residue echo signal at a receive rate; and

a second rate matching block having an input adapted to receive the residue echo signal, the second rate matching block being adapted to generate an error signal at the transmit rate.

2. The echo canceller of claim 1, wherein the receive rate is greater than the transmit rate.

3. The echo canceller of claim 1, the first rate matching block further comprising an up sampling block having an input adapted to receive the output signal of the echo canceller, the up sampling block being adapted to generate an up-sampled signal by a zero filling operation.

4. The echo canceller of claim 3, the first rate matching block further comprising an interpolation filter having an input adapted to receive the up-sampled signal, the interpolation filter being adapted to generate a filtered signal, wherein the interpolation filter is a low pass filter.

5. The echo canceller of claim 4, the first rate matching block further comprising a down sampling block having an input adapted to receive the filtered signal,

the down sampling block being adapted to generate a down sampled signal by dropping a predetermined number of samples.

6. The echo canceller of claim 1, the second rate matching block further comprising an up sampling block having an input adapted to receive the residual echo signal, the up sampling block being adapted to generate an up-sampled signal by a zero filling operation.

7. The echo canceller of claim 6, the second rate matching block further comprising an anti-aliasing filter having an input adapted to receive the up-sampled signal, the anti-aliasing filter being adapted to generate a filtered signal by filtering at least one frequency signal above a transmit band, wherein the anti-aliasing filter is a fixed low pass finite impulse response filter.

8. The echo canceller of claim 7, the second rate matching block further comprising a down sampling block having an input adapted to receive the filtered signal, the down sampling block being adapted to generate a down sampled signal by dropping a predetermined number of samples.

9. The echo canceller of claim 1, wherein the error signal is used to adaptively train at least one coefficient of the echo canceller filter.

10. The echo canceller of claim 9, wherein least mean square update rules are used to adaptively train the at least one coefficient.

11. The echo canceller of claim 1, wherein the receive rate is equal to a multiple of a transmit rate by a rate factor.

12. The echo canceller of claim 11, wherein the rate factor is equal to a fraction comprising a down sampling factor divided by an up sampling factor.

13. A dual rate echo canceller for applications with asymmetric transmit and receive rates, the echo canceller comprising:

a rate matching block having an input adapted to receive a transmit signal from a transmit path, the rate matching block being adapted to generate an output signal at a receive rate; and

an echo cancellation filter having an input adapted to receive the output signal, the echo cancellation filter being adapted to generate an echo signal representative of an echo associated with the transmit signal at an output, wherein the echo signal is subtracted from an incoming receive signal for generating an error signal at the receive rate.

14. The echo canceller of claim 13, wherein the echo cancellation filter is an adaptive finite impulse response filter.

15. The echo canceller of claim 13, wherein a transmit rate is greater than the receive rate.

16. The echo canceller of claim 13, the rate matching block further comprises an up sampling block having an input adapted to receive the transmit signal, the up sampling block being adapted to generate an up-sampled signal by a zero filling operation.

17. The echo canceller of claim 16, the rate matching block further comprises an anti-aliasing filter having an input being adapted to receive the up-sampled signal, the anti-aliasing filter being adapted to generate a filtered signal by filtering at least one frequency signal above a receive band.

18. The echo canceller of claim 17, wherein the anti-aliasing filter is a fixed low pass finite impulse response filter.

19. The echo canceller of claim 17, the rate matching block further comprises a down sampling block having an input being adapted to receive the filtered signal, the down sampling block being adapted to generate a down sampled signal at the receive rate by dropping samples at a predetermined factor.

20. The echo canceller of claim 13, wherein the error signal is used to adaptively train at least one coefficient of the echo canceller filter.

21. The echo canceller of claim 20, wherein least mean square update rules are used to adaptively train the at least one coefficient of the echo canceller filter.

22. A method for implementing a dual rate echo canceller for applications with asymmetric transmit and receive rates, the method comprising the steps of:

receiving a transmit signal from a transmit path at an input;

generating an output signal comprising a signal component representative of an echo signal associated with the transmit signal at an output, wherein the input and the output of the echo canceller filter are sampled at a transmit rate;

receiving the output signal;

generating a first output, the first output being subtracted from an incoming receive signal yielding a residue echo signal at a receive rate;

receiving the residue echo signal; and

generating an error signal at the transmit rate.

23. The method of claim 22, wherein the receive rate is greater than the transmit rate.

24. The method of claim 22, wherein the step of generating a first output further comprises the step of:

generating an up-sampled signal from the output signal by a zero filling operation.

25. The method of claim 24, further comprising the steps of:

receiving the up-sampled signal; and

generating a filtered signal by a low pass filter.

26. The method of claim 25, further comprising the steps of:

receiving the filtered signal; and

generating a down sampled signal by dropping a predetermined number of samples.

27. The method of claim 22, wherein the step of generating an error signal further comprises the step of:

generating an up-sampled signal from the residual echo signal by a zero filling operation.

28. The method of claim 27, further comprising the steps of:

receiving the up-sampled signal; and

generating a filtered signal by filtering at least one frequency signal above a transmit band.

29. The method of claim 28, further comprising the steps of:

receiving the filtered signal; and

generating a down sampled signal by dropping a predetermined number of samples.

30. The method of claim 22, wherein the error signal is used to adaptively train at least one coefficient of a echo canceller filter.

31. The method of claim 30, wherein least mean square update rules are used to adaptively train the at least one coefficient.

32. The method of claim 22, wherein the receive rate is equal to a multiple of a transmit rate by a rate factor.

33. The echo canceller of claim 32, wherein the rate factor is equal to a fraction comprising a down sampling factor divided by an up sampling factor.

34. A method for implementing a dual rate echo canceller for applications with asymmetric transmit and receive rates, the method comprising the steps of:

receiving a transmit signal from a transmit path;

generating an output signal at a receive rate;

receiving the output signal; and

generating an echo signal representative of an echo associated with the transmit signal at an output, wherein the echo signal is subtracted from an incoming receive signal for generating an error signal at the receive rate.

35. The method of claim 34, wherein the step of generating an echo signal further comprises implementing an adaptive finite impulse response filter.

36. The method of claim 34, wherein a transmit rate is greater than the receive rate.

37. The method of claim 34, wherein the step of generating an output signal further comprises the step of:

generating an up-sampled signal from the transmit signal by a zero filling operation.

38. The method of claim 37, further comprising the steps of:

receiving the up-sampled signal; and

generating a filtered signal by filtering at least one frequency signal above a receive band.

39. The method of claim 38, the step of generating a filtered signal further comprises the step of implementing a fixed low pass finite impulse response filter.

40. The method of claim 38, further comprising the steps of:

receiving the filtered signal; and

generating a down sampled signal at the receive rate by dropping samples at a predetermined factor.

41. The method of claim 34, wherein the error signal is used to adaptively train at least one coefficient of a echo canceller filter.

42. The method of claim 41, wherein least mean square update rules are used to adaptively train the at least one coefficient of the echo canceller filter.

43. The echo canceller of claim 1, wherein a least mean square update rule is applied to train at least one coefficient of the echo canceller filter, the least means square update rule is defined as

$$\mathbf{w}_{n+1} = \mathbf{w}_n - \mu e(n)\mathbf{X}_n^T\mathbf{h},$$

where $\mathbf{w}$ represents a coefficient vector, μ represents step size, $e(n)$ represents the error signal, and $\mathbf{X}_n^T\mathbf{h}$ represents a vector-matrix product where $\mathbf{X}$ is a Hankel matrix and $\mathbf{h}$ represents a filter coefficients vector.

44. The echo canceller of claim 43, wherein

$$e(n) = y_r(n) - \mathbf{h}^T\mathbf{X}_n\mathbf{w},$$

where $y_r(n)$ is a received signal component.

45. The echo canceller of claim 1, wherein a least mean square update rule is applied to train at least one coefficient of the echo canceller filter, the least means square update rule is defined as

$$\mathbf{w}_{n+1} = \mathbf{w}_n - \mu e(n)\mathbf{x}_{n-d},$$

where $\mathbf{w}$ represents a coefficient vector, μ represents step size, $e(n)$ represents the error signal, and $\mathbf{x}$ represents a data vector.

46. The echo canceller of claim 45, wherein

$$e(n) = y_r(n) - \mathbf{h}^T\mathbf{X}_n\mathbf{w},$$

where $y_r(n)$ is a received signal component, $\mathbf{h}$ represents a filter coefficients vector, $\mathbf{X}$ represents an input data matrix, $\mathbf{w}$ represents a coefficient vector.

47. The method of claim 22, wherein a least mean square update rule is applied to train at least one coefficient of the echo canceller filter, the least means square update rule is defined as

$$\mathbf{w}_{n+1} = \mathbf{w}_n - \mu e(n)\mathbf{X}_n{}^T\mathbf{h},$$

where $\mathbf{w}$ represents a coefficient vector, μ represents step size, $e(n)$ represents the error signal, and $\mathbf{X}_n{}^T\mathbf{h}$ represents a vector-matrix product where $\mathbf{X}$ is a Hankel matrix and $\mathbf{h}$ represents a filter coefficients vector.

48. The method of claim 47, wherein

$$e(n) = y_r(n) - \mathbf{h}^T\mathbf{X}_n\mathbf{w},$$

where $y_r(n)$ is a received signal component.

49. The method of claim 22, wherein a least mean square update rule is applied to train at least one coefficient of the echo canceller filter, the least means square update rule is defined as

$$\mathbf{w}_{n+1} = \mathbf{w}_n - \mu e(n)\mathbf{x}_{n-d},$$

where $\mathbf{w}$ represents a coefficient vector, μ represents step size, $e(n)$ represents the error signal, and $\mathbf{x}$ represents a data vector.

50. The method of claim 49, wherein

$$e(n) = y_r(n) - \mathbf{h}^T\mathbf{X}_n\mathbf{w},$$

where $y_r(n)$ is a received signal component, $\mathbf{h}$ represents a filter coefficients vector, $\mathbf{X}$ represents an input data matrix, $\mathbf{w}$ represents a coefficient vector.